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CARE OF MILK ON THE FARM.

BY

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., October 30, 1897.

SIR: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin an article entitled Care of Milk on the Farm. The paper was prepared by Mr. R. A. Pearson, assistant chief of the Dairy Division, under the supervision of Mr. Henry E. Alvord, chief of that division. It contains considerable information that will, it is believed, be acceptable and useful to a large number of dairy farmers.

Respectfully, D. E. SALMON, *Chief.*

Hon. JAMES WILSON, *Secretary.*

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INTRODUCTION.

IMPURE MILK UNPROFITABLE.

Many dairy farmers are prosperous and have established the fact that the dairy industry can be made to yield good profits, while others, who seem to have the same opportunities for success, fail to find the profitable side. In the endeavor to ascertain the most important causes of failure, expressions of practical men engaged in the different branches of dairy work have been sought. A large number of inquiries were recently sent out from the Dairy Division to butter and cheese makers and others, requesting them to state what part of dairying, in their judgment, is in the greatest need of improvement. The following are some of the replies received:

The delivery of milk by patrons and the proper care of it prior to delivery. Frequently milk is refused on account of its advanced decomposition. (From the manager of a creamery.)

The care and handling of milk on the farm and until it gets to the creamery. (From a butter maker.)

The careful handling of milk and its delivery to the factory in good condition. (From the salesman of a cheese factory.)

Care and handling of milk before it gets to the creamery or cheese factory. (From an operator.)

Taking care of the milk before it gets to the creamery. (From a farmer.)

Handling the milk from the time it leaves the cow until it is put onto the train. (From a milk dealer.)

Very few replies referred to the chemical composition of the milk or to the amount of butter fat it contained. Milk that is poor in fat naturally, or because it has been adulterated by skimming or watering, does not now give the butter or cheese maker much concern. Since the introduction of the fat test and the system of paying for the amount of fat delivered instead of for the bulk of milk there is no strong temptation to water or skim.

In reply to the many statements received, of which a few are quoted above, and in answer to numerous inquiries on the same subject, an attempt is here made to review some of the most valuable information available, and to explain the causes of changes in milk, the most common ways in which it is contaminated, and how to keep it pure. Reference is made to winter as well as to summer dairying, because that branch is rapidly developing and promises to become of

great importance. Complex data of scientific experiments are not given, and technical explanations are omitted as far as possible.

On a large proportion of dairy farms many of the fundamental principles which should be observed in producing pure milk are almost entirely overlooked. This is usually due to lack of appreciation of their importance more than to intentional neglect. In most cases bad conditions are promptly improved when their dangers are known. Special knowledge is as necessary in conducting the dairy as in other occupations. When one understands something of the sciences affecting dairying, the changes in milk cease to be mysterious, unexplainable phenomena, and the work connected with the dairy, instead of being unprofitable, uncertain, and monotonous, as some consider it, may become profitable, interesting, and instructive.

The value of milk when it is delivered to the factory depends largely on the care it has received previous to delivery, and its condition as well as its fat content should influence the price paid for it. Every dairyman knows that the handling of milk the first few hours after it has come from the cow has a great influence on its quality and the quality of the products made from it. The care of milk seems a simple matter, but better methods in our dairies are of the greatest importance to the success and reputation of American dairying.

It is to the interest of every patron of a creamery or cheese factory that the milk used shall be the best and purest that can be produced. Anyone who increases his monthly check by adulterating his milk, accepts payment for what he did not deliver, and is stealing that amount from others to whom it belongs, but anyone who delivers badly contaminated milk to a creamery does even worse. His milk may spoil the entire production of the day, and thus largely decrease the returns to every patron. Butter and cheese makers should absolutely refuse to accept milk that is tainted or unfit for use; they must do this in justice to themselves and to patrons who deliver good milk.

The attempt has sometimes been made to estimate the losses caused by skimming and watering, and enormous amounts are named, but it is not believed that these nearly equal the losses caused by taints or changes in the milk due to neglect. In contracts and agreements the expression "pure milk" should not be taken to mean simply milk having a normal chemical composition, but freedom from all unnecessary contamination; the word *pure* should be understood in its broadest sense.

BACTERIA.

When left to itself, under ordinary conditions, animal and vegetable matter sooner or later undergoes a change; these changes are familiar to everyone as decay, decomposition, putrefaction, or rot. The most common change of milk is known as *souring;* but there are many other fermentations, all of which were once supposed to be due to ill health of the cows, to foods eaten, to thunderstorms, etc. It is now known

that changes of milk and other organic matter are caused by very small vegetable organisms called germs, micro-organisms, or bacteria. Different forms of these little creatures produce different effects. Some accomplish useful or harmless changes, while a few, known as pathogenic bacteria, produce disease in their host.[1] If none of them were present no fermentative change would take place. But they are abundant in nature, and manage in some way to get into most organic substances.

Many persons think of the term bacteria as relating to a disease of some kind; they fail to appreciate that among these micro-organisms man has friends as well as enemies. They are great scavengers, and they have a most important connection with agricultural processes; in manufacturing certain products their action is depended upon almost

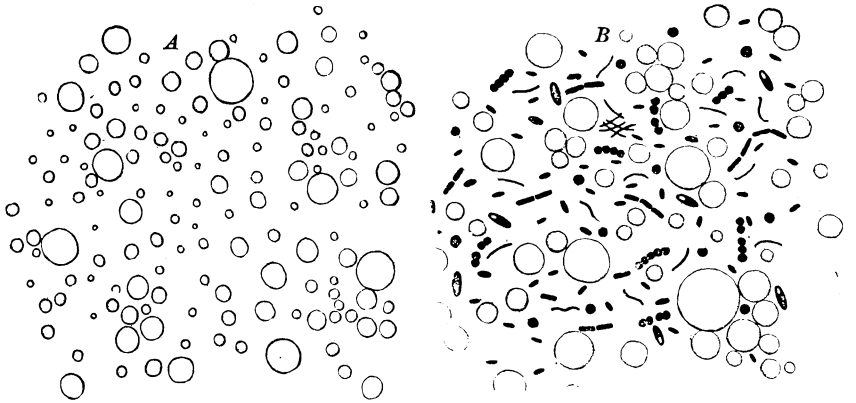

FIG. 1.—Microscopic appearance of pure and impure milk: *A*, pure milk; *B*, after standing in a warm room for a few hours in a dirty dish, showing, besides the fat globules, many forms of bacteria (Moore). This latter appearance is obtained only with the aid of a high-power microscope.

entirely; they are absolutely necessary in the manufacture of fine butter and in giving variety to cheese.

DESCRIPTION OF BACTERIA.

Bacteria are so small that it is difficult to form a conception of their size; it would require many hundred of them in a continuous line to extend an inch. A thousand billion of them, if placed together, would weigh but a small part of an ounce. In a single drop of badly infected milk the bacteria may be counted by the million. It is evident that they can not be seen with the naked eye, but require to be highly magnified in order to be identified. (Fig. 1.) Bacteria are not all of the same size nor the same shape, nor do they all grow alike under the same conditions. Their differences in these respects aid in classifying them.

They are composed of a single cell, and the most common way by

[1] The term "host" is applied to the subject infested, whether animate or inanimate.

which they reproduce themselves is by the division of the "parent" cell into two smaller cells. This is accomplished by the bacterium gradually becoming more and more constricted about the middle until it separates into two parts; these increase in size, and the process is constantly repeated. Under favorable conditions multiplication takes place with great rapidity. A bacterium may develop and be ready to reproduce itself in a few minutes.

Another form of reproduction of bacteria is by spores. These correspond to seeds of plants, and are usually formed under circumstances not favorable to the continued development of the bacteria and their multiplication by division. Like the seeds of wheat, the spores can endure conditions which would be fatal to the growing form, and after surviving such conditions they quickly develop when more favorably situated. Some spores have been found to retain their powers of germination for more than ten years.

CONDITIONS AFFECTING BACTERIAL GROWTH.

Three things are essential for the growth and development of bacteria; they are food, warmth, and moisture, and when these are furnished, as they are to a greater or less extent in every dairy, the multiplication of bacteria takes place. Some species require other conditions besides those named; certain ones must have access to air, while others can not thrive in the open air; some require to be in an acid medium, but to most species a medium having a neutral or alkaline reaction is necessary; darkness is requisite to some and preferred by most species; their growth is checked by bright light, and direct sunlight is fatal.

The food elements required by bacteria are present in the constituents of milk, and they are in a readily available state. Nitrogen, carbon, oxygen, and mineral matter are essential and are furnished by the casein, albumen, milk sugar, and mineral salts. The butter fat is of little importance as a food for germs.

Bacteria thrive within wide limits of temperature. The degree of heat has an important effect on their growth. Some species do best at a high temperature, near blood heat, while others prefer a lower temperature. Every person who has handled milk knows that if kept a long time in a moderately warm place it undergoes quite a different change from that which takes place at a high temperature. The reason for this is that different degrees of heat are favorable to different species of germs. The species favored rapidly increases and covers up the work of others less favored, but which may continue to grow slowly. At about 90° F. most forms grow with great rapidity, the rate of their multiplication decreasing with the decrease of temperature. Bacteriologists have shown that at 93° F. certain germs may increase in number in four hours more than two hundred fold, while at 55° F. their increase is only about eight fold. An experiment is reported

in which a difference of 18 degrees in the temperature of two samples of milk caused, in fifteen hours, a difference of almost 75,000,000 bacteria per cubic centimeter.[1] This shows very plainly how much the rate of growth of bacteria depends upon temperature.

At 50° F. bacteria are quite inactive, but at this and considerably lower degrees of heat they retain life, and some forms continue to multiply. Freezing does not kill them. Some species can withstand a temperature of many degrees below zero, and with the return of suitable conditions again commence to grow.

Up to a certain point the higher temperatures have the same effect as cold, i. e., make the germs inactive. But when the heat is raised to 125° F. some are killed; others, not harmed by this temperature, are destroyed by greater heat. A sufficient temperature to kill almost all of the growing forms found in milk is 165° F. Spores require still more heat; some can withstand boiling temperature, 212° F.

If milk is heated high enough to kill all the living forms of bacteria and then suddenly cooled to a low temperature, it will keep sweet a long time, because it is free from growing germs. It must be quickly cooled, however, or the spores will develop while the temperature is ranging from 110 down to about 60 degrees, and the bacteria thus formed may continue to increase slowly after the cooling is completed, at the low temperature at which the spores would not have germinated. When milk is heated for the purpose of killing bacteria (the process is called pasteurization or sterilization) it should be held at the highest temperature at least ten minutes, as some forms are not killed by a short exposure to the same temperature which is fatal to them in a longer exposure. In dry air much higher degrees of heat than those named are necessary to kill bacteria. For this reason steam is generally used instead of dry heat for sterilizing utensils.

Bacteria also require moisture. It is well known that dead organic matter quickly disintegrates when it is in a moist condition and its changes are arrested when it is dried. Milk being a fluid, all the moisture that is necessary for micro-organisms is at hand. There is no danger of food being too dilute for bacteria; some forms do well even in distilled water. In milk, germs seem to find ideal conditions.

The chief agents that are antagonistic to bacterial increase are, together with light, the opposites to the first three favorable conditions mentioned above, viz, lack of food, extremes of temperature, and dryness. These are the dairyman's most important weapons, and when he has learned to use them properly he need have no fear of milk souring too soon or being otherwise affected by germs. The operator of a creamery or factory is also sometimes able to take advantage of the fact that certain species of bacteria are antagonistic to each other and can not grow well together if they are in the milk at the same time. In

[1]One centimeter is about the same as two-fifths of an inch, and a cubic centimeter is about equal to half a thimbleful.

such a case there is a battle for existence, the kind having the smaller number to start with, or being less favored than the other by temperature or other conditions, is usually overcome. Thus one can at times cut off the effects of undesirable bacteria by giving advantages to other desirable or harmless forms that are hostile to them. This is what takes place when the butter maker adds a "starter" to his cream and ripens it at a high temperature as rapidly as possible to prevent the increase of a taint which he may discover in the milk. A starter is a preparation or culture containing large numbers of the peculiar kind of bacteria that ripen cream; by its use proper forms of fermentation are started in milk or cream.

When micro-organisms are growing, new products are formed from the constituents of the medium by which they are surrounded. For example, the lactic acid bacteria, which are the most numerous about a dairy, and which cause milk to sour, change the sugar of milk to lactic acid. After a certain amount of acid or other product of growth has been developed, some bacteria can not longer thrive; the surroundings are so changed by their own operations that they cease to increase. This fact, however, is not of much practical value to the milk producer; the fermentation of his milk should never be allowed to proceed so far that it stops itself.

Bacteria cease to grow when in the presence of certain chemicals. When these are added to milk they are known as preservatives; when they are used for such purposes as killing the germs in or about a dairy they are known as disinfectants. Both of these will be referred to later.

DAIRY BACTERIA.

The greatest number of bacteria are to be found where their food is most abundant. Animals, feed, manure, and milk are all hosts or breeding grounds for bacteria. For this reason, the dairy is a place where myriads of germs of different kinds are to be found. They must be always kept in mind, studied, and persistently fought or controlled.

NUMBER OF BACTERIA IN MILK.

Milk ordinarily contains large numbers of bacteria. It is one of the few media that is well adapted to almost any species and quickly becomes inhabited with large numbers of those which obtain entrance to it. There may be from a few hundred to many million in a single drop, depending upon its exposure and the time and opportunity the germs have had for increasing. Dirt in milk is a sure sign of large numbers of bacteria. As the rate of increase is influenced by temperature, the number present at any time also depends much upon the previous temperature of the fluid. Russell has shown that the weather has a marked influence on the bacterial content. He examined the milk of a patron on two successive days, the first being warm and the second cold

and rainy; 1 cubic centimeter contained, respectively, 1,150,000 and 48,000 bacteria, or about one-twenty-fifth as many on the cold, wet day as on the warm day. It is apparent that this difference was due chiefly to the purity of the atmosphere and a lower temperature. Another investigator counted from 50,000 to 100,000 germs per cubic centimeter of the first milk drawn. In some cases the last milk is sterile, or germ free; in others it contains numerous germs. City milk usually contains from 10,000 to hundreds of thousands of bacteria in a single cubic centimeter.

The number of bacteria in a sample of milk is an indication of its purity, but not an absolute proof that it is or is not of good quality. Large numbers of harmless bacteria are sometimes found in good milk. It is the harmful ones, and those that are liable to become harmful if present in too large numbers, that chiefly concern the dairyman. If they are kept out of the milk, or their growth is controlled, the number of harmless ones will also probably be reduced, for the measures which restrict one class have a like effect on the other. Whenever large numbers of harmless germs are found, there is probability that dangerous forms are included.

KINDS OF DAIRY BACTERIA.

Over 200 different kinds of dairy bacteria are found in milk and its products, new and old. Many of these have not been completely described and will require much more study before their characteristics are fully understood. Different forms are found in different sections of the country. Different sources of contamination contribute different types of bacteria to the milk, and the large number of forms does not seem strange when their many sources are studied. One would expect to find a difference in kinds as well as in numbers of bacteria in milk of cows kept in pasture and milked in the open air, and in milk of cows continuously stabled. Such is the case. Especially is this true in regard to the germs of manure, which are more abundant in the stable than out of doors. As a result of their struggle for existence, frequently a smaller number of species is in milk after it has stood than when perfectly fresh, although the number of individuals may have greatly increased.

For practical purposes, dairy bacteria may be separated into three classes, as follows: (1) Harmless bacteria; (2) useful bacteria; (3) harmful bacteria.

(1) **Harmless bacteria.**—These are the most numerous of the forms found in milk. They are of comparatively small direct importance to the milk producer, but they are not in milk when first secreted and, as suggested above, if they obtain entrance to it they are evidence that other germs also have had an opportunity to plant themselves.

(2) **Useful bacteria.**—Some forms of bacteria are essential to dairy operations. Cream is generally allowed to ripen or sour before it is

churned—in other words, useful bacteria are given conditions favorable to their growth, and they cause acid to develop. Butter flavor depends upon several conditions, but one of the most important is the action of certain bacteria which, in the process of maturing or ripening, produce the desired aroma and flavor—cultures of bacteria for this purpose are now regularly sold on the market. The chief differences between varieties of cheese is caused by the kinds of bacteria that grow in them. Bacteria needed in some cases are not wanted in others, so the same species which are useful at one time may at another time be harmful.

(3) **Harmful bacteria.**—These form the most important class. They may be subdivided into two groups, viz, those having an injurious effect on the milk, and those not apparently affecting the milk but having an injurious effect on the health of the consumer. Many species fall in only one of these subdivisions; others belong to both.

Certain bacteria may be indirectly injurious by producing conditions favorable for other germs which are directly injurious, but not able to grow in milk until its nature has changed. For example, a species which causes bitter milk does not thrive until the ordinary sour milk (lactic acid) germs have developed some acidity. It is not necessary to go into details as to the many different changes produced directly and indirectly by numerous forms. Some are troublesome whenever they find their way into the milk, others become a nuisance only when they are present in very large numbers. Types that color the milk, form gas, or produce disagreeable flavors are always objectionable. Farmers' Bulletin No. 29 treats more fully and technically of the bacterial changes of milk. The bad effects of those bacteria which produce a pronounced change in milk are usually confined to the milk itself. Its change is so marked that it is rarely used as food.

Some bacteria thrive in milk and do not have a marked effect on it but may cause disastrous results to the consumer. These are germs of disease and should be most carefully guarded against. Good proof exists of the transmission of several diseases by milk, and in a number of instances epidemics have been traced to an infected milk supply.

Another kind of bacterial action which may indirectly result in injury to health is referred to by Conn. He states that some of the common milk bacteria may be present in such great numbers as to produce poisonous toxins "which are directly injurious to the weak stomach of the infant or of the invalid." Many cases of cholera infantum and similar troubles are said to be due to these causes.

All forms of bacteria are objectionable in milk that is to be consumed as food in its natural state, and, indeed, most forms are undesirable in milk that is to be manufactured.

HOW MILK BECOMES IMPURE.

After learning something of the characteristics of bacteria and their abundance in milk, natural questions of interest are, How do they get into milk? and, How can they be kept out of it? This is an unpleasant subject when looked at from its worst side, but methods of producing milk are constantly being improved, especially in dairies which send milk to cities having proper regulations, enforced by boards of health or city milk inspectors, and in dairies supplying well conducted creameries and cheese factories.

The causes of impure or unnatural milk will be discussed under three heads:

I. Diseased animals and persons, and unnatural conditions.
II. Uncleanliness in the stable.
III. Uncleanliness outside of the stable.

I. DISEASED ANIMALS AND PERSONS, AND UNNATURAL CONDITIONS.

SPREAD OF INFECTIOUS DISEASES.

Contamination of milk by the germs of disease is the most dangerous form. Some infectious diseases attack animals and man alike, and if a cow is suffering with one of these she is a menace not only to the whole herd, but to persons who consume her product, for her milk may readily act as a carrier of germs to the consumer. It has been found that in certain diseases, especially when the udder is affected, the germs may be in the milk at the time it is drawn; then no amount of protection after milking will assure freedom from disease-producing bacteria.

Tuberculosis, or consumption, is the disease that is most common and most to be feared. Much has been written on this subject, and it is unnecessary to here discuss the particular conditions that cause the malady or aid its progress. In the advanced stages of tuberculosis the milk becomes unnatural in appearance, but sometimes even before the udder is known to be affected it may contain the specific germs, called bacilli tuberculosis.

An English authority holds that diphtheria may similarly be transmitted from the cow to the milk consumer, and this seems to be true of scarlet fever, or a closely allied disease. Foot and mouth disease and anthrax are some of the others that may infect the milk. It is fortunate that when the animal is affected with some of these dangerous diseases the milk flow stops. It is also fortunate that most of these diseases do not occur, or are very rare, in this country.

Milk may be the means of conveying to the consumer germs of diseases from other persons. For example, if any of the attendants have a contagious disease, or are at any time exposed to such, the air about them and their surroundings is more or less infected, and the germs may easily get into the milk in ways described on the following pages.

The most important diseases whose germs enter the milk from

external sources are typhoid fever, diphtheria, scarlet fever, cholera, and tuberculosis. Numerous outbreaks of typhoid fever have been reported where there was no doubt about the milk supply being the carrier of the germs, they having gained entrance to it from external sources, such as infected water or a person who had nursed or been otherwise exposed to a typhoid-fever patient. Outbreaks of diphtheria have been traced to milk from farms where diphtheria was known to exist in the families of the attendants. The same is reported of scarlet fever and cholera.

ABNORMAL MILK AND SLIGHT VARIATIONS.

Other factors than bacteria may influence the appearance and composition of milk at the time it is drawn and render it impure or unnatural. The cow's health is an important factor; but abnormal milk is also due to excitement of the cow, temporary disorder, bad treatment, injury, time from calving, and substances eaten. And all of these causes may seriously affect the quantity as well as the quality of milk. Some of them are responsible for sudden slight variations in the quality of milk, as shown by the regular tests, and which frequently seem so mysterious and without cause.

When a cow is diseased she may continue to give milk, but it is liable to be abnormal in composition. The fat may be reduced to a quarter of the usual amount, so that the milk appears skimmed, or the fat may be abnormally increased. Being "in heat" or "off feed" has a similar but less marked effect.

Excitement of the cow affects the milk; even changing the stall may slightly alter its composition. The cow is an animal of regular habits. She expects to be milked at a certain time and to be fed at a certain time, and becomes more or less uneasy if the usual programme is not carried out. A change of milkers may result, for a few milkings, in a reduced yield or in milk of poorer quality.

Many slight variations in the quality and quantity of milk may be charged to neglect. The farmer who leaves his cows out in a bleak storm should not be surprised to find that his test at the factory has fallen, while that of his neighbor whose cows were sheltered, did not fall. One of the first functions of food is to maintain the bodily heat, and when necessary it will be used in this way instead of forming milk. Thus, the state of the weather, temperature, and storms affect the milk to a greater or less degree. Dairymen are all aware that bad treatment or neglect quickly results in decreased profits. The brutal treatment of a cow by an attendant, by kicking, beating, or otherwise, is not without effect on her milk. Bloody milk is often caused by an injury to the udder, which may have been inflicted by a thoughtless attendant. Sometimes the "boss of the herd" is to blame for such injuries to the weaker animals.

The natural variation of milk due to the time since calving is of course unavoidable; it is so gradual and so slight that sudden changes can

not be attributed to this cause. The first milk given after parturition is known as colostrum; it contains an excessive amount of albumen, and its other constituents are not in the same proportions as later. Within a few days it becomes natural, and gradually grows richer in fat as the period of lactation advances. Colostrum is unfit for use except as food for the young calf.

The influence of food upon the quality of milk is a subject which has received much attention. Foods undoubtedly have some effect on the quality of milk produced, but it is not as marked as supposed by many; the breed and individuality of the cow is of greater importance. Slight variations in composition are caused by a sudden change of feed, and milk is sometimes rendered disagreeable by taints caused by the cows eating turnips, onions, garlic, sour ensilage, ragweed, or other strongly flavored feeds or weeds.

II. UNCLEANLINESS IN THE STABLE.

The largest part of the impurities found in milk get into it in the short time after it is drawn from the cow and before it leaves the stable. This brief period may be called the critical time in the history of dairy products. In many stables myriads of bacteria are entering the milk every minute it remains exposed, being carried there by many kinds of foreign matter, some of which would do no harm were it not for the germs it brings. Grotenfelt mentions the following impurities which he found in unstrained fresh milk: Manure particles, fodder particles, molds, fungi, cow hairs, particles of skin, human hairs, parts of insects, down from birds, small bits of wood, woolen threads, linen threads, fine threads, soil particles. It is evident that these different kinds of foreign matter are derived from numerous sources, but the bulk of the impurities consists of ordinary stable dirt, chiefly manure, and its presence in quantities, in milk, is evidence of slovenly methods. Over 50 grains of this matter have been found in 100 pounds of milk, and when it is remembered that it contains myriads of bacteria of the forms causing putrefaction and decomposition, it does not seem strange that milk is soon affected by its presence. Germs introduced in this way, in large numbers, may act as poisons to the delicate consumer and cause severe intestinal troubles.

Dirt gets into the milk when in the stable, principally from three sources, viz, the cows, the milkers, and the air. But this classification is unnecessary for stables which are carelessly cleaned only once or twice a week, and in which it is impossible for an animal or person to remain any length of time and come out undefiled; in such places there is a constant shower of bacteria.

Exterior and interior views of buildings where the production of pure milk would be impossible are shown in figs. 2 and 3. Any building rapidly going to ruin would fall in this class, but the illustrations show new structures especially erected for dairy purposes. The small building on the right is the dairy house. Note the general appearance of shiftlessness about the buildings and the absence of windows or other

provision for light and ventilation. The pails, cans, and strainers are left in impure stable air, and the dairy house is supplied with air which

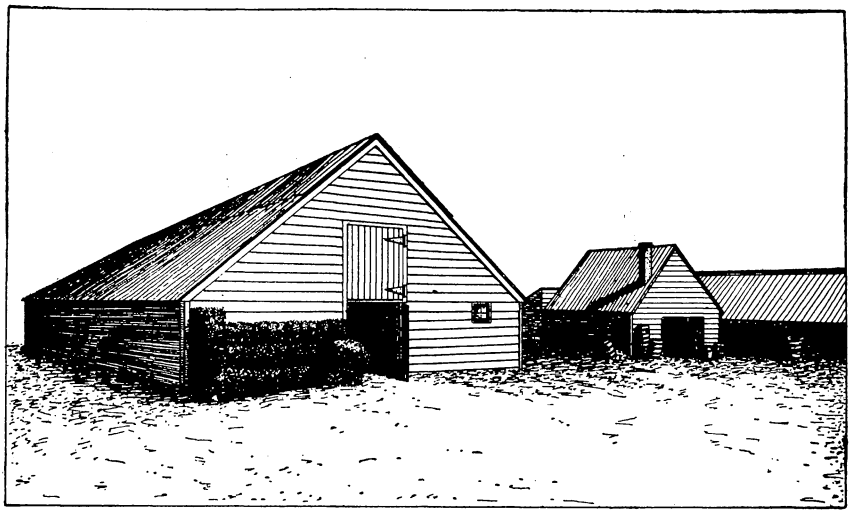

FIG. 2.—Cow stable and dairy house improperly located and constructed, and poorly cared for.

has just passed over heaps of manure. Many stables are so dark that it is impossible even at midday to see one's way in them, and they are

FIG. 3.—Interior view of an unsanitary cow stable.

so close that it is a relief to get out into the fresh air after being inside for a few minutes.

DIRT FROM THE COWS.

The cows supply most of the dirt to milk, as anyone will admit if he is at all familiar with the conditions in many stables. It is not uncommon to see cows covered with so much dust that the color of their backs can not be seen; their flanks, hips, and sides are sometimes plastered with layers of manure.

When the work of cleaning the cows is neglected, it is impossible to keep milk even decently clean when milking. Large lumps of dirt, hairs, and straws are continually falling into the pail. The hairy coat is an excellent harbor for dirt and bacteria, and every time anything touches the skin, or the udder or surrounding parts are disturbed, a shower is precipitated. As more or less violent motion always occurs at milking, the loosely adhering particles are easily dislodged just at a time when the milk pail is in a position to collect them.

UNTIDY ATTENDANTS.

Untidy attendants constitute another source from which milk is contaminated. They frequently turn from cleaning the horses, or other equally dirty work, to milking the cows, with no thought of their unfitness to handle milk. On some farms milking is regarded as the dirtiest of all work, and the milkers prepare for it accordingly. Dust adheres to the milker's clothes almost as readily as to the cow's coat, and it easily falls from his shoulders and sleeves into the pail; his hands and finger nails also contribute a share to the contamination. Thus he may be the means of conveying to the milk as many kinds of germs as fall from the cow, and in addition to these he may transmit human diseases, as referred to above.

DUST-LADEN AIR.

Air is a source of germs found in milk. It is not a medium capable of supporting bacteria by itself, but it carries more or less of small particles of dust and organic matter in suspension, and these have many bacteria in and upon them. On account of the dust constantly being raised the number of organisms in the air of a stable may be considerable, especially if dry feed stuffs are used and the manure is allowed to become dry on the floor. Over 100 different kinds of organisms have been found in a single quart of stable air. These do not increase in numbers while floating about, but they quickly commence a vigorous growth when they fall into fresh, warm milk. As dust is constantly tending to settle, the largest number of bacteria is to be found near the floor, and a vast number may fall into a milk pail or can in a very short time.

In some cases stable air contains so much dust, and milk is exposed to it so long, that it is the chief means of contamination. Most of the dirt in the air is from dry, dusty fodder and bedding. When hay is

thrown down through chutes, the air is quickly filled with dust, and air currents and the constant shaking of the hay by the animals keep the dust from settling. Some rises every time the bedding is disturbed, and it is naturally most abundant beneath the cow during milking.

FOREMILK.

Although milk is sterile when it is first secreted, it is extremely difficult to obtain sterile milk from the udder, because some germs succeed in finding their way to it even before it is drawn. A few drops of milk are always left in the teat after the milking is done; and the end of the teat remains moist. Germs from the air and from the dirt on the udder or bedding quickly plant themselves in this thin layer of fresh milk and rapidly increase in numbers. Some work up through the orifice into the cavity of the teat and milk duct, and those kinds which do not require a supply of air for growth find most favorable conditions there, and the milk in the vicinity of the teat becomes contaminated by their increase. In this way lactic acid, or sour milk, bacteria, which later become so abundant, commence their work before the milk is drawn from the udder. Sometimes this form of contamination is quite serious, the first milk, or "foremilk," serving to affect the whole mess.

III. UNCLEANLINESS OUTSIDE OF THE STABLE.

What has already been said about improperly kept stables applies equally, in the main, to an unclean dairy building or room. Milk will not remain pure if stored in an unclean place. One of the chief faults in the care of a dairy room is in allowing it to remain continuously damp. The sloppy methods so often practiced are favorable to bacteria.

The two most important sources of contamination after the milk has left the stable are unclean dairy utensils and impure water; although these often affect the milk while in the stable, the trouble is usually due to their own improper care or infection elsewhere.

Utensils are sometimes made of poor material or are so complicated or irregular that milk is not completely removed from them and furnishes legions of bacteria to the next lot of milk with which they come in contact. Wood has so many pores that it is almost impossible to clean it. The supposed economy of using old, dilapidated vessels of any kind, those having double bottoms, patches, dents, or bare places from which tin has been worn, frequently results in impure milk. Neglected strainer and wiping cloths, and promiscuous rags used for drying, are important sources of contamination.

Cleaning utensils is an operation sadly neglected on many dairy farms; certain articles, as coolers, whose use is intended to improve the milk, are sometimes so poorly cleaned that they contaminate the milk more than they purify it. Milk pails washed only in cold or lukewarm water soon become covered with a greasy, sticky layer of foreign

matter. Dirt is often allowed to accumulate about the necks of cans and in little grooves or ridges under the shoulders, and careful dairymen are surprised to find these accumulations when they investigate the places hidden from view. Such conditions are most liable to be found when the same cans used for delivering milk are used for returning to the farm, waste products in which numerous kinds of fermentations are progressing. The milk receiver sometimes sticks labels on such cans to call special attention to their condition. This is a good plan.

Water from cisterns, shallow wells, or streams, or that which has been long exposed to the air, can not be relied upon as pure. It is liable to contain many forms of vegetable life. Sometimes surface drainage, or the seepage from privy vaults or barnyards, finds a way through the ground to a well, yet the use of the water is continued without knowledge of its dangerous qualities. In this manner water used in a dairy has spread typhoid fever.

If impure water is supplied to a dairy it may affect the quality of the milk indirectly by injuring the health of the cows. But its first effect is to contaminate the milk directly by the water which remains on the utensils when they are not properly dried and sterilized, or by water which is purposely added for adulteration. Frequently milk is stored in tanks of water. This water is rapidly fouled by the dirt on the bottoms and sides of the cans, or by impure ice, milk slopping over, and by rinsing various articles in it, and it thus becomes another means of contamination.

HOW TO KEEP MILK PURE.

Experiments have shown that the contamination of milk occurring under ordinary circumstances can be reduced over 95 per cent by taking care to avoid all possible sources of impurity and conditions favoring germ growth. The fact that bacteria are usually attached to larger bodies makes the work of preventing their entrance into milk comparatively easy. But with all the care that it is practicable to observe, some bacteria will get into milk; therefore it must be cooled as soon as possible and held at a low temperature to prevent their multiplication. The different steps through which milk passes might be compared to the links of a chain—if one is weak the strength of the whole chain is impaired; so if the care of milk is neglected at any step the care taken at other times may be rendered useless.

Brief references will be made to each step in the production and care of milk, from the herd to the delivery of the milk to the creamery, cheese factory, or train.

THE HERD.

The first requisite for pure milk is healthy cows. Any animal suspected of being sick or out of condition should be immediately separated from the herd and not allowed to remain near the dairy. If the

milk from such animals is used it must first be boiled. On every dairy farm there should be a proper place for keeping sick or suspected animals. It is absurd to claim that any large herd can be constantly maintained in perfect health, and when one finds a dairy farm with no provision for the care of sick animals, he has good cause to suspect that the milk from that place can not be implicitly relied upon for its purity.

When a herd is known to be sound, every precaution should be taken before adding new animals. In one case carelessness in this respect resulted in the loss of about 100 cows that had been in good health until a few fresh milkers, supposed to be also healthy, but later proved to be tuberculous, were introduced into the stable. The tuberculin test has proved to be a reliable means of ascertaining the presence of tuberculosis, and its use in any suspected herd is advisable. It does not injure the animals and may be the means of detecting cases that could not otherwise be found, but yet be a source of infection to sound animals. It should be applied only by a competent veterinarian, and after a herd has been tested no animals should be added to it unless known to be free from the disease.

There is little danger of a healthy cow giving abnormal milk if she is well cared for and not allowed to be excited, or unnecessarily disturbed. For this reason it is customary to have certain attendants always care for the same animals. But on some large dairy farms this practice is not followed, the claim being made that cows are satisfied with any attendant as soon as they become accustomed to frequent changes. No dog, unless it has been well trained, should be allowed in the pasture or barnyard, and the herd should never be driven rapidly to or from the pasture. If a cow is in the habit of hooking others she can usually be quieted by dehorning.

Bad effects of feeds may be avoided by changing them gradually and avoiding the use of those which give flavor to the milk—if the latter must be used, the best time is soon after milking. Cows may safely be allowed to graze in a pasture containing some garlic if they are stabled several hours before milking, and given dry feed. Such articles as turnips, onions, sour ensilage, etc., should not be stored in the stable, as their odor is imparted to milk through the air.

The proper time for commencing to use milk after calving is easily decided by its appearance and taste, and its behavior when boiled. Colostrum contains much more albumen than normal milk, and this coagulates into a solid mass when heated.

The cleaning of the cow is too often considered of small importance. Every milch cow should be carefully curried and brushed daily, and the udder and lower parts should always be brushed just before milking. Animals not accustomed to this care may object to it at first, but with gentleness and patience on the part of the attendants they soon learn to expect it and to stand quietly during the operation,

which contributes to their own comfort. It is not enough to clean only the lower parts, leaving the back and sides; the work should be thoroughly done. Some dairymen groom their cows as carefully as horses are groomed in the best stables, their coats are kept smooth and shining, and one need never fear soiling his hands by touching them.

A stiff, open brush does good work in removing dry matter, but soft and damp manure should be scraped from the hips and flanks, and when necessary this should be followed by a washing or repeated washings. It is generally recommended to carefully wipe the udder, teats, and surrounding parts with a damp cloth just previous to milking. This is for the purpose of moistening the dirt and bacteria, which if left dry are apt to be shaken off during the milking. Washing or wiping the udder or in any way agitating it before being ready to draw the milk is objected to by some milkers, who believe that this action makes the cow think she is to be immediately milked, and when the attendant returns half an hour later the usual amount or quality of milk is not obtained. Not a few practical dairymen make a regular practice of cleaning all the udders before milking is begun and notice no bad effects. It is probable that cows become accustomed to the cleaning and learn not to expect to be milked until the milker appears with the pail. Care should be taken not to make the parts too wet or the impure water will drip into the pail; they should be only slightly dampened. It is also necessary to use care lest the cow take cold by being washed. The work of cleaning may be lightened by having the hair clipped about the udder and on the flanks, and by the use of clean bedding, not too fine.

The herd requires the most attention when continuously stabled. But it is almost as necessary to clean the animals when pastured as at other times, especially if they are permitted to wade in slimy pools. Wading in clean water is not objectionable, but cows should always be kept out of foul or sluggish water. The barnyard ought to be so well drained that stagnant pools of water are never seen there. If this is impossible, the pools should be fenced to keep the cattle out.

THE EMPLOYEES.

Contamination from attendants may be easily avoided. A dairyman should know the condition of health of every employee connected with his dairy, and of all the members of their households. If at any time a contagious disease appears, the patient should be excluded from the dairy premises and all communication between the house and dairy should cease until the danger is past. The same care should be taken to keep any person who has been exposed to a contagious disease away from the milk. Those working in a dairy should not enter a house where there has been a contagious disease until it has been properly disinfected.

The personal cleanliness of the attendants is often neglected. They should be clean in appearance and in habits. Clothes and hands require special attention. Outer garments, used for dairy work only, should be worn, and they should be cleaned often. If a separate suit is kept for milking and is hung in the stable and never aired, it looks and smells badly and is soon worse than the regular work clothes. White material that can be washed is the best for dairy suits. The objection made against white goods that they show dirt quickly is really in their favor. When a suit is soiled it should show it and be cleaned. On model dairy farms the suits are washed daily; this is not a difficult task, as they never become much soiled and they may be rough-dried. A hat or cap should be used, to prevent hairs falling into the pail from the milker's head. If an entire special suit is not used when milking, one loose outer garment at least should be worn.

Just before milking the milker's hands ought to be washed. His finger nails should be clean, and they should be kept short and smooth at all times. An abundance of water and soap should be available and used. Some recommend washing the hands after each cow is milked; neglect of this has resulted in unconsciously carrying a disease, such as inflammation of the udder, to sound animals. Care must be taken not to let the hands touch the milk, as the skin always has more or less excretions on it, and these help to contaminate the milk. The hands should be kept dry, and if there are any sores they must be carefully covered before milking. Dirt and milk rubbed into an abrasion on hands or teats cause ugly sores. Smoking or any use of tobacco while milking should never be tolerated, and clothing impregnated with the odor of tobacco should be discarded.

THE STABLE.

The place where the herd is kept and its care are second in importance only to the health of the animals. Infection from stable air can be largely avoided by using special care in feeding and cleaning. The air should not be full of dust at milking time. Some advocate the use of a special room for milking only. The effect of milking in pure air is shown by an experiment in which a cow was milked in an open field on a damp morning when the air was clear, and it was found that her milk contained only a few bacteria in the same volume which, under ordinary conditions in the stable, contains many hundred. No dusty food should be fed just previous to milking. If it is believed to be necessary for the cows to be eating at milking time, they may be given a moist feed then and the dry fodder used after milking. The animals and stables should be cleaned early and the stable well ventilated before milking is commenced. In a light, dry building, in hot weather, it is well to sprinkle the floor to settle the dust and lower the temperature.

Moldy hay or straw must not be used for bedding cows, as the special bacteria which they carry are liable to produce harmful changes in the milk. Clean straw or new shavings make the best bedding. In many

places dry shavings (fig. 4) from planing mills can be obtained at a trifling cost; in some cases they are in such demand for this purpose as to be baled, shipped, and sold for four or five dollars a ton. Coarse stuffs for bedding are unsatisfactory, as they are usually poor absorbents and are uncomfortable for the animals and difficult to handle. No sensible dairyman will attempt to economize by using the refuse from the horse stalls for bedding cows. Clean sand is found to be a fairly good absorbent, but, like sawdust, it gets into the hair and makes extra work in cleaning.

Cow stables should be kept clean all the time; a little attention once or twice daily is not sufficient. If the cows are kept continuously in their places, an attendant should pass through the stables several times

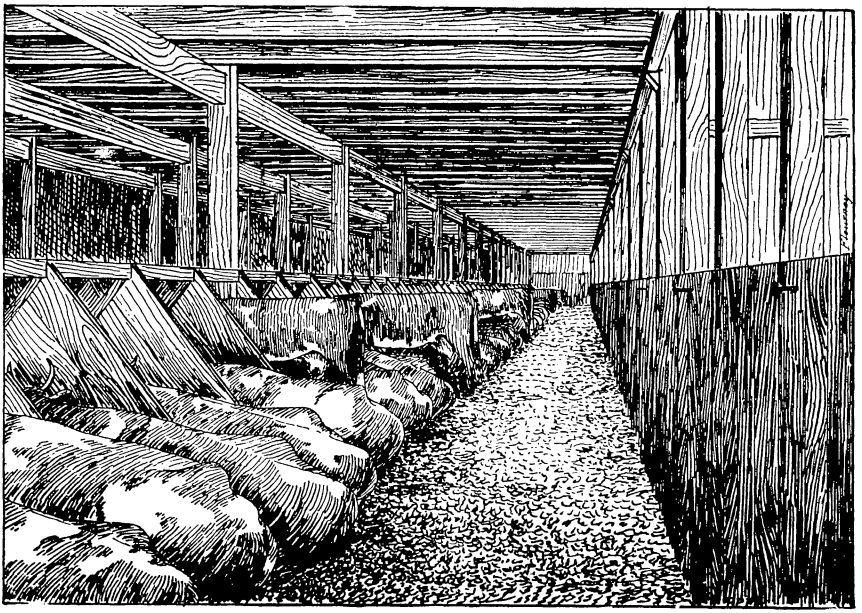

FIG. 4.—Stable in which shavings are used for bedding.

a day and remove all droppings. When the herd is large, a boy or man may well be continuously employed for this purpose. This is more necessary than formerly, on account of the high feeding usually practiced and the consequent soft manure of disagreeable odor. It is well to make free use of land plaster for the purpose of absorbing moisture and undesirable odors, as well as increasing the value of the manure.

At certain periods, depending upon the thoroughness of the daily work, the stables should be given extra careful and complete cleanings. The following directions may appear formidable, but they call for nothing more than is frequently done in many model dairies. No nook nor corner should be overlooked. All manure and fodder should be taken out, the six sides of every room swept, any rotten woodwork

replaced, loose boards secured, dried accumulations about mangers, etc., removed, and the mangers scrubbed with hot water and soap, sal soda, or lye. If the floor is earth, it should be removed to a depth of a few inches and refilled with fresh material. After this work has been done, it is well to go over the walls, ceiling, floor, stalls, etc., with hot steam direct from a boiler. Such careful cleaning should be followed by a coat of whitewash, which may be applied quickly and satisfactorily with a spray pump. It acts as a disinfectant and makes the building lighter. Care should be taken to have it penetrate all cracks and crevices. Whitewash may be easily made by mixing 60 pounds of water with 100 pounds of quicklime. To each quart of this mixture 5 quarts of water are added. Salt or glue are sometimes used to improve the quality. It should be applied at least twice a year. A receipt for whitewash, recommended by the Light-House Board of the United States Treasury Department, and in successful use for many years, is as follows:

Slake half a bushel of unslaked lime with boiling water, keeping it covered during the process. Strain it and add a peck of salt, dissolved in warm water; 3 pounds of ground rice put in boiling water and boiled to a thin paste; half a pound of powdered spanish whiting and a pound of clear glue, dissolved in warm water; mix these well together, and let the mixture stand for several days. Keep the wash thus prepared in a kettle or portable furnace, and when used put it on as hot as possible, with painters' or whitewash brushes.

DISINFECTION.

When milk has a strong taint at the time it is drawn, the trouble is usually not due to bacteria, and it can be improved by aeration (see p. 30). But when it is natural at first and gradually becomes more and more tainted the longer it is held, bacteria are probably to blame, and if the dairy is badly infected with them energetic measures are often required to get rid of them. If the affected milk is not harmful to health, but only objectionable on account of its smell or taste, its entire loss may be made unnecessary by pasteurizing or sterilizing it as soon as possible after it is drawn and before much of a change has been made, and then using it immediately or keeping where further infection can not take place. But this treatment does not affect the source of the trouble, and if that is not overcome by sterilizing all utensils and practicing scrupulous cleanliness everywhere, the disinfection of the stable or the killing of all the germs must be undertaken. Disinfection is also necessary if cattle have been affected with a contagious disease, and it should be done as soon as the last case is cured or removed and before other cattle are added to the herd. While the germs of some diseases are delicate and can live only a short time outside the body of their host, others are hardy and retain their vitality for months or years. Sunlight is a great purifier and should be admitted in abundance. The same may be said of fresh, pure air. Both of these aid in disinfection.

Whitewash partially serves the purpose of disinfection; it should soon follow other agents which are employed when more thorough work must be done. Before disinfection, the stable should be carefully cleaned as above detailed, and any fodder which may have been stored where it was exposed should be destroyed.

Chemical disinfectants are efficient for thorough work. Most of these are poisonous and must be handled with great care. The cost is an important consideration in the selection of disinfectants for cheap buildings. The following are comparatively inexpensive: Bichloride of mercury or corrosive sublimate, in the proportion of 1 part to 1,000 of water, or 1 ounce to 8 gallons of water, is an effective agent. The poison should first be dissolved in a small amount of hot water and then diluted; it may be applied with a brush or as a spray. One pound of chloride of lime to 3 gallons of water is another effective disinfectant. Carbolic acid is well known; it should be used in the proportion of 1 part to 20 of water.

Sometimes it is best to use a gas as a germicide. In this case no animal nor person can remain in the inclosure being disinfected. It must be tightly closed so there will be no leaks through cracks or other openings. When sulphur is burned the building is soon filled with its fumes. A considerable quantity should be supplied and fresh air excluded for twenty-four hours, to give full time for the gas to penetrate into every place where germs may be lodged. Chlorine gas is a more powerful disinfectant. It is generated by chloride of lime and muriatic acid. The fumes are very deadly, and great care must be taken not to inhale it. Formaldehyde is an efficient germicide which has recently come into use; it is a gas generated by special apparatus; it may also be applied in a solution.

One of the best and cheapest disinfectants for floors, gutters, waste pipes, etc., is sulphate of iron (copperas). For a floor, as much of this should be dissolved as water will hold; it is then applied with a sprinkler. Lumps of dry copperas are useful for purifying drains.

After a stable has been disinfected it should be allowed to remain empty several days for thorough airing.

CONSTRUCTION OF THE STABLE.

The construction of the stable has an important influence on the health of the cattle which it shelters, the way they are cared for, and the degree of cleanliness that exists. Unhandy, inconveniently arranged buildings are often the cause of much which should be done being left undone; especially is this true of the work of cleaning. The stable should be well located, and planned to facilitate the work of caring for the herd and to contribute to its comfort and well-being. Light and fresh air are essentials, and should be admitted in abundance.

A hard, smooth material, which does not absorb liquids and has no cracks, is the best for the stable floor. The stalls should be comfortable, not too long nor too short, and the gutters in the rear should be open, shallow, and with sufficient incline to carry off the liquid manure. High mangers are objectionable; some farmers feed on the floor to avoid mangers (fig. 5). Every stable should be as simply constructed as possible. (See Farmers' Bulletin No. 55, U. S. Department of Agriculture, The Dairy Herd: Its Formation and Management.)

THE DAIRY HOUSE.

The location of a dairy house, or room, must be carefully selected. On some farms it is found convenient and not objectionable to have

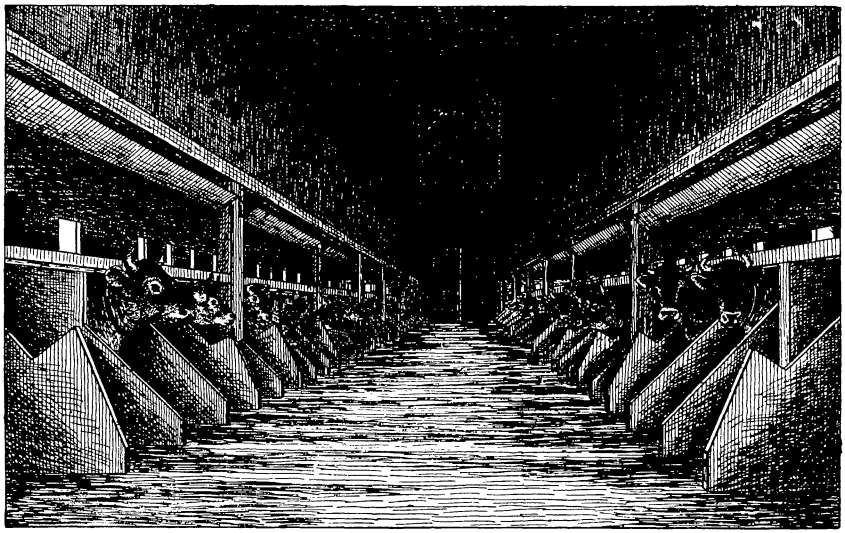

FIG. 5.—Well-built stable arranged for floor feeding. (The watering troughs are lowered when needed.)

it adjacent to or very close to the stable. It should be placed where it will not be reached by odors from the barnyard, and should be separated from the room in which the cattle are kept by two doors, or situated so it will be necessary to pass out of the stable before entering the dairy room. Special attention must be given to facilities for drainage. It is necessary to carry the waste a considerable distance from the building. An attempt should be made to keep the surroundings dry. The room should be thoroughly dried out, in all its parts, at least once a day. If shelves are of wood, they should be painted. The greatest care must be taken to keep all surroundings clean from fermenting or decaying milk, as well as other forms of dirt; even sour milk ought not to be allowed to remain in the dairy room where there is other milk which should be kept sweet.

UTENSILS.[1]

It is a mistake to purchase poor utensils or to keep them after they are badly worn. New cans and pails are frequently the cheapest means of improving the output of a dairy. In the selection of appliances, great care must be taken to get those which are simply constructed and can be easily cleaned. Pails, strainers, cans, and dippers—in fact, everything that comes in contact with the milk—should be well made, and there should be as few places for germs to attach themselves as possible. Vessels for holding milk should be made of a hard, smooth material. Wood is not adapted to this purpose. Many small utensils are now made of pressed tin and are free from seams.

The cleaning of every dairy utensil should be done promptly and thoroughly, first using cold or slightly warm water for rinsing, then hot water with a cleaning preparation, then clean hot water for rinsing, and finally boiling water or steam for sterilizing. Straining and wiping cloths also require careful attention. Of the special preparations for aiding in cleaning, sal soda or washing soda is one of the best. It would be a convenient arrangement for patrons of a creamery or factory to be supplied with this where their milk is delivered; they might also be furnished with brushes, strainers, pails, etc., at the same place, at cost price.

Boiling water is a satisfactory sterilizing agent, but heat must be almost continuously applied or the temperature will quickly fall to a point below which bacteria are not killed. Steam is a more effective sterilizing agent, and if there is much of this work to be done, a small steam generator will be found useful. If a feed cooker is located close to the dairy, its boiler may serve to supply all the steam that is needed. It is an excellent practice to have cans cleaned and sterilized at the factory, where arrangements for such work can be made. After being cleaned, utensils must be kept in clean places and in pure air.

WATER.

A supply of good water is of the greatest value to a dairy. Spring or well water which comes from a considerable depth is the best, as it is the most free from micro-organisms and is cold. Careful attention should be given to protect the water supply from the entrance of surface water, which is always rich in bacterial life, and is especially liable to get into the well or spring during the rainy season. It is also important to make sure that the supply is not contaminated by drainage from residences. The well should be located at a distance from any piles of filth or other contaminating influences; it is advisable to have the water examined occasionally by a bacteriologist. State and local boards of health make such examinations. A good way to help

[1] This subject is discussed at length in an article entitled "Care of dairy utensils," in the Yearbook of the U. S. Department of Agriculture for 1896. It has also been printed in separate form.

keep a well pure is to use from it freely; the water should never be allowed to become stale. Water is not purified by freezing, so if ice has been cut from a stagnant pond, or is formed from impure water, care must be taken to keep it from coming in contact with dairy products.

MILKING.

Milking is an operation which requires skill, as it has an important effect on the amount and quality of milk given. Dairymen know that there are as great differences between milkers as between cows, and that cows will do much better with some milkers than with others. Indeed, good cows are often almost ruined by poor milkers.

The milker should avoid handling the cow more than is necessary, and he should make it a rule to do his work quickly and thoroughly. He should never go from a sick to a well cow without first cleansing his hands. The habit of wetting the hands with milk is filthy in the extreme and should never be practiced. Some people think it is necessary, but this is a mistake. The hands should be kept dry. If they are not, it is impossible to prevent drops of milk from constantly falling from them into the pail.

The pail should be held close to the udder, so as to expose the milk to the air as little as possible. The farther the streams fall, and the more they spray, the more dirt and bacteria they collect. Contamination from the foremilk may be avoided by discarding the first few streams drawn, or less than a gill in all. This entails little loss, as the first milk drawn is always poor in butter fat, and if it happens to be badly contaminated, as is frequently the case, much injury and trouble may be saved.

Milkers should be constantly on the lookout for unnatural milk, and when it is discovered, it should not be mixed with the rest, but boiled and fed to stock, or thrown away.

REMOVAL OF MILK FROM THE STABLE.

Milk must be removed from the stable as soon as possible after it is drawn to avoid germs and characteristic stable odors which it readily absorbs. It is not uncommon to see a large can placed in the passageway between the cows, where it is slowly filled and allowed to remain until the cows are turned out and the chores finished. It may be more than an hour from the time the first milk was drawn until it is cooled. Such delay must not be allowed if it is expected to keep the milk in good condition. Each pail, as soon as it is filled or when the milking of any cow is finished, should be carried to the dairy room. If a dairy house is located at a distance from the stable, the cans should be taken to it as soon as they are filled; and they should not be so large as to require a long time for filling. When there are many milkers and large cans are used, the cans may be carried to the dairy house by suspending them on a skeleton frame between two wheels, or they may be sent across on a cable stretched from the barn to the dairy house.

STRAINING.

If milk could be drawn in such a manner that no dust or dirt fell into it, straining would be needless. But this is impracticable, and it is necessary to remove foreign matter by some mechanical means. The sooner milk is strained the better. It should pass through a metal strainer having a fine mesh and a flannel cloth or cheese cloth folded enough to prevent running through too fast. Both the cloth and metal strainer ought to be frequently rinsed during the milking to avoid gumming and to wash away fine particles of dirt removed from one pail which might be later carried through, leaving the milk as badly infected as it would have been if not strained. The dirt should be removed from the milk so completely that when the milk is again strained at its destination there will be no cause for returning the cloth through which it passed to show to the dairyman the dirt collected.

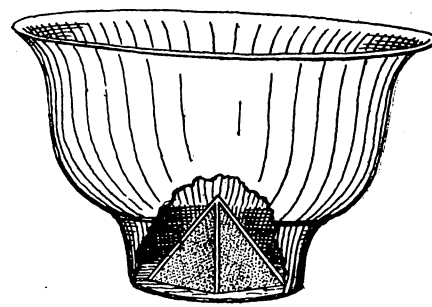

FIG. 6.—Pyramidal strainer.

Milk pails are sometimes used whose tops are covered with tin, the center of which is replaced by a circular piece of wire gauze about 7 inches in diameter, through which the streams of milk pass. This form of pail is of advantage in keeping out hairs or large pieces of dirt. When the milk is emptied from these pails it should be passed through a cloth, and the pail and its strainer should be rinsed. The common strainer pail should not be used in the stable. It offers no special protection to the milk and may even collect dirt that would otherwise be avoided.

The common strainer used over cans has flaring sides and a concave bottom, the wire gauze being in the center of the bottom. This only partially serves its purpose. It removes coarse materials, but holds them in the milk stream, and the soft impurities which are easily broken up by agitation and soaking, may be forced through the small openings by the constant current of milk.

Numerous improved forms of strainers are now made, and some of them are very simple, and effectively overcome the objection to the old style. In the pyramidal form (fig. 6) the center of the metal gauze is raised and the straining surface is much increased; impurities striking against it work down until out of the current. Others are so arranged that the milk is rising when it passes through the gauze (fig. 7) and dirt held back falls to the bottom of a settling chamber. A layer of cotton between two pieces of cheese cloth and pieces of wire netting to keep it in place, removes many fine particles which escape other materials. Cotton is cheap, and when much milk is handled one can easily afford

to use it once and throw it away. Sand and gravel are used as strainers or filters, but special care must be taken to thoroughly clean and sterilize them. Filters are also used, the milk being forced through them by pressure.

When passing through the strainer large surfaces of the milk are exposed; hence it is important to do this work in a pure atmosphere.

AERATING THE MILK.

Aeration of milk is its exposure to the air for the purpose of removing "animal odor" or other taint. It is generally regarded by milk shippers and other handlers of milk as a useful operation. The benefit derived from aeration depends on how much the milk is tainted or "off." The product of a healthy cow, obtained with due regard to cleanliness and feeding, has little or none of the "cowey" odor. But it is different when the cow is slightly out of condition, is illy kept, or has been given some strongly smelling food previous to milking; then aeration has a beneficial effect, and although the taint is not entirely removed, it is reduced. It is of use chiefly in removing odors absorbed from the air or from food eaten by the cow; both these are the strongest when the milk is first drawn, while those caused by bacteria are least noticeable when the milk is fresh, and increase when it is held. (See Disinfection, p. 24).

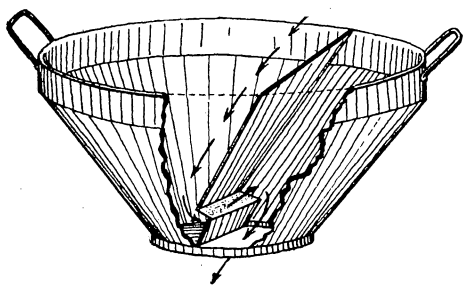

FIG. 7.—Strainer in which the milk is rising as it passes through the gauze.

Milk is said to be "smothered" when it is tightly closed in a can immediately after milking, without cooling or the removal of the gases which it contains. When thus treated it soon becomes unfit for use. Cans with holes in their lids are used to prevent this trouble, but ventilation is unnecessary if aeration is practiced. All taint should be out of the milk before the lid is put in place.

Aerating does not have a marked effect on the keeping quality of milk; its benefit is in removing undesirable odors. Some persons of sensitive taste can not drink unaerated milk, but relish it when aerated. The operation is done with varying success in several different ways. Usually the milk is cooled more or less at the same time it is being aerated, and it is due to this that its souring is retarded. Actively stirring or agitating milk serves to partially aerate it, and this should always be done if arrangements for more thorough work are not at hand. A better method is to dip from the can a few quarts and pour it back slowly from a height. This should be repeated many times, depending upon how much taint there is and the quantity of milk; or the milk

may be poured from one vessel to another with the same effect. Still more thorough work is accomplished by allowing it to fall through the air in fine streams or a spray. A milk pail with small punctures in the bottom and held a few feet above a larger receptacle answers for this purpose. Special apparatus is made to operate in the same way.

By other contrivances the air is carried to the bottom of the vessel, whence it rises through the milk in bubbles, bringing out with it the objectionable gases, until they are mostly removed. This requires from one to five minutes, and is done by a concave plunger or by a pipe and bellows. With the latter arrangement air can be filtered through cotton to free it from impurities before it is introduced into the milk. Certain aerators are constructed so that the milk passes over them in a thin layer and is thus exposed to the air. These are referred to in connection with cooling.

Here again the necessity of fresh, pure air must be emphasized. It is better to omit aeration entirely than to attempt it in a stable or a close, foul place. As with other work in the dairy, promptness is necessary in aerating if best results are sought. The aerator should be large enough to care for the milk as fast as it is brought from the cows. Even though it may be intended to use the morning's milk immediately, it should be aerated the same as night's milk.

Experiments conducted by private enterprise seem to show that even the strong odor of garlic, which gives so much trouble and causes great losses in certain districts every spring and fall, can be entirely removed by heating milk and aerating it while hot. It is explained that the volatile oil, carrying the disagreeable odor, is liberated by heat and carried away by the fresh air. This process necessitates the pasteurization of the milk, which is far less objectionable than having a garlic flavor in the butter, and may even be beneficial to the product.

Much taint can be prevented by cleanliness. The so-called "animal" or "cowey" odor is generally to be attributed, not to natural milk, but to the exterior of the cow from which it is taken, or to the unclean person who does the milking, or to filthy surroundings where the milking is done. Aeration is a means of only in part overcoming these neglects.

COOLING OF MILK.

When milk is for cheese or butter making and is to be soon used or promptly delivered at the factory, it may be cooled sufficiently by thorough aeration on the farm. But if it is not at once hauled away or is not to be immediately separated or set for cream, or must be carried a long distance, or is to be used in its natural form as food, fermentation must be checked by low temperature. Cooling is the only important operation in the dairy which should ever be modified, and then only under the conditions named. It is often stated that milk does not require so much care when it is to be used for butter or cheese making as when it is to be sold at retail. This is true in a way, only as far as

the cooling is concerned, and it is very misleading. First-class butter or cheese can not be made from inferior milk; for the factory, milk should be drawn and handled with all the precautions against contamination, the same as if it were to be sold at retail; but it need not be held at a temperature so low that the germs of lactic acid can not increase. A certain amount of acidity is necessary for cheese or butter making, and this may be allowed to partially develop in the milk before it leaves the farm without harm to the product. Some cheese makers prefer that the temperature never be allowed to go below 60° F.

The lower the temperature to which milk is cooled and held, the longer it can be kept in good condition. It is the custom of some dairymen to serve their customers soon after milking and without first cooling the milk. In such cases it is impossible for it to long remain sweet, and within a few hours it undergoes more change than milk usually sold in cities; this is because the latter was promptly cooled and kept cold, although it may have been one or two days old when delivered.

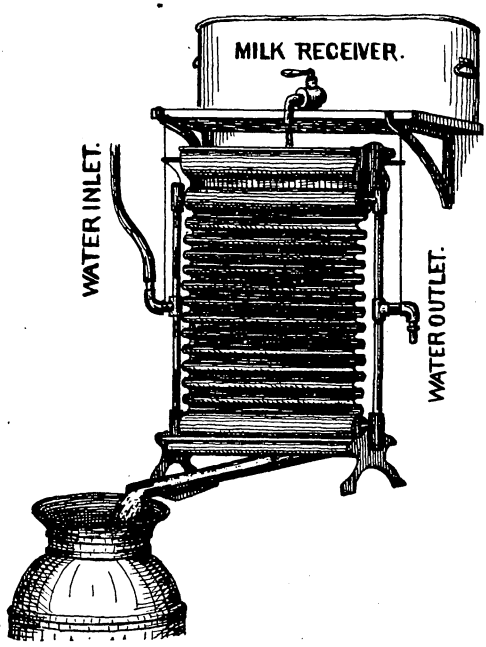

FIG. 8.—Milk cooler for use with running water.

It is hardly necessary to emphasize the importance of prompt and rapid cooling when the rate at which germs multiply in warm milk is understood. The milk from one cow should be cooled while that from the next is being drawn. This is good for the milk, and it saves a tiresome delay of waiting for it to cool after all the milking is completed. It is not sufficient to set a can in a cold place and allow it to cool slowly; this requires several hours and gives time for the germination of spores and the development of bacteria. In order to get full advantage of low temperature the cooling must be completed at the earliest possible moment, and it should be carried down to about 40° F. At temperatures above 40° F. and below 60° F. some species of bacteria thrive, though they do not cause as much trouble or loss as those which grow at still higher degrees. Milk from dairies where cooling is not practiced is frequently sour or tainted when it arrives at the factory; in such cases cooling is a preventive needed, and the labor necessary will be well repaid by the better product.

A common way of cooling is to place the can in a trough or vat of water and stir the milk; this is a tiresome operation, and the work is liable to be slighted; if the can is only half filled the temperature falls faster than when it is full. Putting ice into milk or cream must be done with caution; water is thus added, and there is danger besides of adding many impurities and germs which are not destroyed by freezing.

Cooling is so closely connected with aerating that the terms are often confused. Machines are constructed for the double purpose of performing both these operations at the same time. These are more efficient than setting in water and occasionally stirring by hand, and they are not very expensive. Milk may be cooled by such contrivances from 30 to 40 degrees in a few minutes. Coolers having a current of water running through them (fig. 8) at the same time milk is running over the outside, cool the milk to within 3 or 4 degrees of the temperature of the water; such thorough work requires several times as much water as the bulk of milk. The best results are obtained when the cooling agent enters the cooler at the bottom and leaves at the top, so the milk is partly cooled before it receives the effect of the coldest water. Where running water is not available, a form of cooler is used which holds a volume of water to which ice has been added (fig. 9). A cooler should be simply constructed, having all parts easily accessible for cleaning.

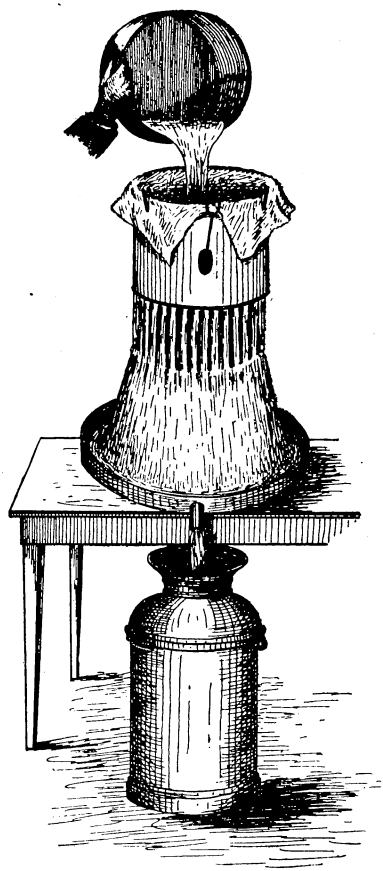

FIG. 9.—Milk cooler for use with a volume of water, not running, and ice.

It is desirable for every dairy farm to have a never-failing cold spring, a good well, or a supply of ice, so that means for cooling milk will always be at hand. If ice is stored near the milk room and the business is large enough to justify the arrangement, a circulation of brine through pipes below the ice and through the milk cooler may be arranged, the cold brine being forced about the circuit by a pump. The drippings from the ice may also be used. The cooling of milk should receive the same attention in winter as in summer.

STORING OF MILK.

A large proportion of the milk delivered to factories is first held on the farm from twelve to twenty-four hours and some times two or three days, and the conditions under which it is stored during this time have an important influence on its quality. Low temperature does not kill bacteria; it only renders them torpid and they regain their activity as soon as they are again surrounded by warmth; therefore it is as necessary to *hold* the milk at a low temperature as to cool it in the first place. As in cooling, for certain uses of the milk, very low temperatures are unnecessary, it should not be allowed to freeze.

The usual way of storing milk is to set the cans in tanks of cold water. Care must be taken to have at least three times as much water as milk and to have it higher on the outside of the cans than the milk is inside. If the milk is higher than the water a thin layer on top is not cooled so much as the rest, fermentation progresses there, and as soon as the can is moved this layer is disturbed and distributes a supply of bacteria through the remainder. The tank should be covered to confine the cold air, and when necessary, ice should be placed on the cans and in the water. If it is attempted to keep the cans cold by placing blocks of ice on them when grouped on the floor, a blanket should be thrown over them. When delivery is not made for thirty-six hours, as on account of holding over Sunday, the milk should be held at a lower temperature than when delivered within twelve or fifteen hours.

In order to prevent the absorption of odors by milk, the place where it is kept must be free from any objectionable smell. Cold milk absorbs odors very rapidly. Water in the tanks must be kept sweet by frequent changes, and the shelves, walls, and floor must always be clean. Covers of the cans may be left on or off, but if there is any danger of contamination, the cans should be closed tightly after the milk gets cold.

Evening and morning milk should not be mixed, especially when the fresh milk has not been cooled. If this is done, the whole lot soon spoils. In order to insure the same quality of milk in each can, large tanks are frequently used for mixing all the milk of one milking. This is a matter of some importance when a sample from one can is used for determining the value of the lot, or when the milk is sold at retail.

The use of preservatives is mentioned at length in Farmers' Bulletin No. 42, U. S. Department of Agriculture, Facts About Milk. Some of them are dangerous to the health of the consumer, and any of them may be harmful if taken regularly in milk. They are prohibited by some State laws, are condemned by leading authorities, and should not be used.

When milk or cream is shipped, it is sometimes desirable to seal the cans; this may be done by means of a wire passing through a hole in the edge of the lid and the handle, the ends secured by a lead seal,

similar to those used on doors of freight cars. The seal presses are sold by dairy-supply firms.

Milk is also sometimes shipped in glass jars in cases, ready to be served to city customers; if properly iced, it does not suffer from exposure to the heat during transit. The jars and packages necessary to carry them are heavy and expensive, but the system has many advantages. Special machines are made by which several jars are filled at the same time.

SKIMMING OF MILK ON THE FARM.

There are great objections to having to care for on the farm, and haul to the factory, a large bulk of milk, when only the cream is needed, and any system which does away with the seemingly useless labor of handling eight or ten pounds for the delivery of one, will be most welcome. In the season of bad roads it is difficult to carry large loads of cans, and sometimes it is impossible to transport milk to the creamery when cream alone might be carried. Besides the advantage of having to haul only a small amount instead of a large amount, it is an advantage to have cream removed on the farm, so that skim milk may be fed when fresh. The gathered-cream system with deep-set milk gives these results only partially.

The plan of having small separators on the farms of patrons is being tried in some districts. The skim milk is thus made immediately available for feeding, and the cream alone needs to be cooled, cared for, and hauled. This system appears to be excellent in certain cases, but just how widely it can be profitably adopted is not yet shown. Experiments in this line will be watched with interest. It is a natural development of the cream-gathering plan, and if successful will be widely adopted. It will do away with the return to the farm of the spoiled contents of a filthy skim-milk tank, as well as the sometimes heated discussions as to how much skim milk belongs to the different patrons. But the most important advantage will be the use on each farm of its own skim milk while fresh and sweet. The chance of young stock taking a disease which may be on a distant farm, whence the germs may be delivered to the creamery and carried away in the skim milk to other farms, is also avoided.

If the milk is to be set for cream, it should be aerated and set when warm. This should be done as soon as the milk is strained. If a machine is used, aeration takes place while it is passing through the separator. Unless it is desired to ripen the cream immediately it must be promptly cooled.

HAULING TO THE FACTORY.

If milk is sold off the farm, the dairyman's care of it does not cease until he has delivered it to the factory or other destination, and then he has a right to insist that it be properly handled, if he is interested in the success of the concern which uses his product.

Milk should be hauled in spring wagons and the cans filled full to prevent churning while on the road. Much trouble is caused by allowing it to stand an indefinite period on a platform in the heat, waiting for the collector; the storage tanks should be placed so it will not be necessary to remove the cans from the water until the wagon is ready to start. A piece of canvas or a blanket thrown over the load, protects the cans from dust and extremes of temperature. In hot weather it is an excellent plan to wet the cloth so that the air underneath will be cooled by evaporation. Padded jackets which slip over separate cans and protect the tops and sides are commonly used when cream is shipped in hot weather. Cheap burlap bags of the proper size, with holes cut for the handles of the cans, may be used to advantage to protect milk from heat during shipment; these covers should be thoroughly wet with cold water.

It is doubtful economy to hold milk in warm weather for every-other-day delivery; some factories require delivery twice a day in the hottest weather. In summer it is well to haul at night to avoid the hot sun. It is important to haul the milk in a clean wagon and to have nothing else in the load that could contaminate it.

Waste products should not be returned to the farm in the same cans used for delivering milk; other vessels should be provided for this purpose. If such hauling is unavoidable, consequent trouble can be reduced by having the skim milk or whey pasteurized or sterilized by boiling, and by keeping the tank clean. Patrons should insist that tanks for waste products be thoroughly cleaned daily.

FIFTY DAIRY RULES.[1]

The following rules are based on the preceding text, and briefly summarize the subject discussed:

THE OWNER AND HIS HELPERS.

1. Read current dairy literature and keep posted on new ideas.
2. Observe and enforce the utmost cleanliness about the cattle, their attendants, the stable, the dairy, and all utensils.
3. A person suffering from any disease, or who has been exposed to a contagious disease, must remain away from the cows and the milk.

THE STABLE.

4. Keep dairy cattle in a room or building by themselves. It is preferable to have no cellar below and no storage loft above.
5. Stables should be well ventilated, lighted, and drained; should have tight floors and walls and be plainly constructed.
6. Never use musty or dirty litter.
7. Allow no strong smelling material in the stable for any length of time. Store the manure under cover outside the cow stable and remove it to a distance as often as practicable.

[1] These rules are printed on one side of a large cardboard for posting in stables and dairy rooms, and will be sent in this form to persons applying for them.

8. Whitewash the stable once or twice a year; use land plaster in the manure gutters daily.
9. Use no dry, dusty feed just previous to milking; if fodder is dusty, sprinkle it before it is fed.
10. Clean and thoroughly air the stable before milking; in hot weather sprinkle the floor.
11. Keep the stable and dairy room in good condition, and then insist that the dairy, factory, or place where the milk goes be kept equally well.

THE COWS.

12. Have the herd examined at least twice a year by a skilled veterinarian.
13. Promptly remove from the herd any animal suspected of being in bad health, and reject her milk. Never add an animal to the herd until certain it is free from disease, especially tuberculosis.
14. Do not move cows faster than a comfortable walk while on the way to place of milking or feeding.
15. Never allow the cows to be excited by hard driving, abuse, loud talking, or unnecessary disturbance; do not expose them to cold or storms.
16. Do not change the feed suddenly.
17. Feed liberally, and use only fresh, palatable feed stuffs; in no case should decomposed or moldy material be used.
18. Provide water in abundance, easy of access, and always pure; fresh, but not too cold.
19. Salt should always be accessible.
20. Do not allow any strong flavored food, like garlic, cabbage, and turnips, to be eaten, except immediately after milking.
21. Clean the entire body of the cow daily. If hair in the region of the udder is not easily kept clean it should be clipped.
22. Do not use the milk within twenty days before calving, nor for three to five days afterwards.

MILKING.

23. The milker should be clean in all respects; he should not use tobacco; he should wash and dry his hands just before milking.
24. The milker should wear a clean outer garment, used only when milking, and kept in a clean place at other times.
25. Brush the udder and surrounding parts just before milking, and wipe them with a clean, damp cloth or sponge.
26. Milk quietly, quickly, cleanly, and thoroughly. Cows do not like unnecessary noise or delay. Commence milking at exactly the same hour every morning and evening, and milk the cows in the same order.
27. Throw away (but not on the floor, better, in the gutter) the first few streams from each teat; this milk is very watery and of little value, but it may injure the rest.
28. If in any milking a part of the milk is bloody or stringy or unnatural in appearance, the whole mess should be rejected.
29. Milk with dry hands; never allow the hands to come in contact with the milk.
30. Do not allow dogs, cats, or loafers to be around at milking time.
31. If any accident occurs by which a pail full or partly full of milk becomes dirty, do not try to remedy this by straining, but reject all this milk and rinse the pail.
32. Weigh and record the milk given by each cow, and take a sample morning and night, at least once a week, for testing by the fat test.

CARE OF MILK.

33. Remove the milk of every cow at once from the stable to a clean, dry room, where the air is pure and sweet. Do not allow cans to remain in stables while they are being filled.

34. Strain the milk through a metal gauze and a flannel cloth or layer of cotton as soon as it is drawn.
35. Aerate and cool the milk as soon as strained. If an apparatus for airing and cooling at the same time is not at hand, the milk should be aired first. This must be done in pure air, and it should then be cooled to 45 degrees if the milk is for shipment, or to 60 degrees if for home use or delivery to a factory.
36. Never close a can containing warm milk which has not been aerated.
37. If cover is left off the can, a piece of cloth or mosquito netting should be used to keep out insects.
38. If milk is stored, it should be held in tanks of fresh, cold water (renewed daily), in a clean, dry, cold room. Unless it is desired to remove cream, it should be stirred with a tin stirrer often enough to prevent forming a thick cream layer.
39. Keep the night milk under shelter so rain can not get into the cans. In warm weather hold it in a tank of fresh cold water.
40. Never mix fresh warm milk with that which has been cooled.
41. Do not allow the milk to freeze.
42. Under no circumstances should anything be added to milk to prevent its souring. Cleanliness and cold are the only preventives needed.
43. All milk should be in good condition when delivered. This may make it necessary to deliver twice a day during the hottest weather.
44. When cans are hauled far they should be full, and carried in a spring wagon.
45. In hot weather cover the cans, when moved in a wagon, with a clean wet blanket or canvas.

THE UTENSILS.

46. Milk utensils for farm use should be made of metal and have all joints smoothly soldered. Never allow them to become rusty or rough inside.
47. Do not haul waste products back to the farm in the same cans used for delivering milk. When this is unavoidable, insist that the skim milk or whey tank be kept clean.
48. Cans used for the return of skim milk or whey should be emptied and cleaned as soon as they arrive at the farm.
49. Clean all dairy utensils by first thoroughly rinsing them in warm water; then clean inside and out with a brush and hot water in which a cleaning material is dissolved; then rinse and lastly sterilize by boiling water or steam. Use pure water only.
50. After cleaning, keep utensils, inverted, in pure air, and sun if possible, until wanted for use.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available:

No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. Pp. 8.
No. 16. Leguminous Plants for Green Manuring and for Feeding. Pp. 24.
No. 18. Forage Plants for the South. Pp. 30.
No. 19. Important Insecticides: Directions for Their Preparation and Use. Pp. 20.
No. 21. Barnyard Manure. Pp. 32.
No. 22. Feeding Farm Animals. Pp. 32.
No. 23. Foods: Nutritive Value and Cost. Pp. 32.
No. 24. Hog Cholera and Swine Plague. Pp. 16.
No. 25. Peanuts: Culture and Uses. Pp. 24.
No. 26. Sweet Potatoes: Culture and Uses. Pp. 30.
No. 27. Flax for Seed and Fiber. Pp. 16.
No. 28. Weeds; and How to Kill Them. Pp. 30.
No. 29. Souring of Milk, and Other Changes in Milk Products. Pp. 23.
No. 30. Grape Diseases on the Pacific Coast. Pp. 16.
No. 31. Alfalfa, or Lucern. Pp. 23.
No. 32. Silos and Silage. Pp. 31.
No. 33. Peach Growing for Market. Pp. 24.
No. 34. Meats: Composition and Cooking. Pp. 29.
No. 35. Potato Culture. Pp. 23.
No. 36. Cotton Seed and Its Products. Pp. 16.
No. 37. Kafir Corn: Characteristics, Culture, and Uses. Pp. 12.
No. 38. Spraying for Fruit Diseases. Pp. 12.
No. 39. Onion Culture. Pp. 31.
No. 40. Farm Drainage. Pp. 24.
No. 41. Fowls: Care and Feeding. Pp. 24.
No. 42. Facts About Milk. Pp. 29.
No. 43. Sewage Disposal on the Farm. Pp. 22.
No. 44. Commercial Fertilizers. Pp. 24.
No. 45. Some Insects Injurious to Stored Grain. Pp. 32.
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No. 52. The Sugar Beet. Pp. 48.
No. 53. How to Grow Mushrooms. Pp. 20.
No. 54. Some Common Birds in Their Relation to Agriculture. Pp. 40.
No. 55. The Dairy Herd: Its Formation and Management. Pp. 24.
No. 56. Experiment Station Work—I. Pp. 30.
No. 57. Butter Making on the Farm. Pp. 15.
No. 58. The Soy Bean as a Forage Crop. Pp. 24.
No. 59. Bee Keeping. Pp. 32.
No. 60. Methods of Curing Tobacco. Pp. 16.
No. 61. Asparagus Culture. Pp. 40.
No. 62. Marketing Farm Produce. Pp. 28.
No. 63. Care of Milk on the Farm. Pp. 40.
No. 64. Ducks and Geese. Pp. 48.
No. 65. Experiment Station Work—II. Pp. 32.
No. 66. Meadows and Pastures. Pp 24.
No. 67. Forestry for Farmers. Pp. 48.
No. 68. The Black Rot of the Cabbage. Pp. 22.
No. 69. Experiment Station Work—III. Pp. 32.
No. 70. The Principal Insect Enemies of the Grape. Pp. 24.
No. 71. Some Essentials of Beef Production. Pp 24.
No. 72. Cattle Ranges of the Southwest. Pp. 32.
No. 73. Experiment Station Work—IV. Pp. 32.
No. 74. Milk as Food. Pp. 39.
No. 75. The Grain Smuts. Pp. 20.
No. 76. Tomato Growing. Pp. 30.
No. 77. The Liming of Soils. Pp. 19.
No. 78. Experiment Station Work—V. Pp. 32.
No. 79. Experiment Station Work—VI. Pp. 28.
No. 80. The Peach Twig-borer—an Important Enemy of Stone Fruits. Pp. 16.
No. 81. Corn Culture in the South. (In press.)
No. 82. The Culture of Tobacco. Pp. 23.

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